PROC. ENTOMOL. SOC. WASH.
89(3), 1987, pp. 448–457

# SPATIAL AND TEMPORAL DISTRIBUTION OF SHORE FLIES IN A FRESHWATER MARSH (DIPTERA: EPHYDRIDAE)

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*Abstract.*—Information is given on the diversity, and spatial and temporal distribution of 25 species of Ephydridae occurring in a freshwater marsh located near Kent in northeastern Ohio (Portage County). Eight different vegetation zones were recognized in the marsh, with the greatest number of ephydrid species (21) occurring in the vegetation type dominated by yellow water lily, *Nuphar lutea* (L.) Sibth. & Smith. It is suggested that the ephydrid community organization in *Nuphar* is influenced by an abundance of high quality food and presence of structural refuges that provide oviposition sites and protection from inclement weather conditions and predators.

The family Ephydridae (shore flies) is one of the largest entities within the acalyptrate Diptera, consisting of over 1400 described species distributed in all the major faunal regions of the world (Rohdendorf, 1974). More than 400 Nearctic species are known (Deonier, 1979) with most species occurring in aquatic and semi-aquatic habitats. Most studies confirm the association of ephydrids with wetlands, although a few workers have reported the presence of ephydrids in more xeric habitats (Bahrmann, 1978; Steinly, 1984). Several species exist in stressful habitats such as crude oil pools (Thorpe, 1930), highly alkaline waters (Wirth, 1971) and thermal springs (Collins, 1975), but most occur in less unusual habitats, including mud shores along drainage ditches (Thier and Foote, 1980), sedge meadows (Scheiring and Foote, 1973), and inland marshes (Deonier, 1965; Todd, 1985).

Information available on the trophic habits of ephydrids indicates that adults and larvae of many species ingest algae (Dahl, 1959; Deonier, 1972; Foote, 1979; Blair and Foote, 1984), whereas other species are saprophagous, feeding on decaying animal tissue (Bohart and Gressitt, 1951; Steinly and Runyan, 1979), or plant detritus (Eastin and Foote, 1971; Busacca and Foote, 1978). Larvae of some ephydrid species are leafminers in wetland macrophytes (Grigarick, 1959; Deonier, 1971), and a few are predators (Sturtevant and Wheeler, 1953; Simpson, 1975).

The present study gives information on the spatial and temporal distribution of adult Ephydridae occurring in a northeastern Ohio freshwater marsh. Data are also given on species richness, diversity, evenness, and similarity for ephydrid assemblages occurring in the 8 different vegetation types found in the marsh. This information is then used to propose factors that may influence ephydrid community organization.

## MATERIALS AND METHODS

The freshwater marsh utilized in this study was located near Kent, Ohio, 0.8 km east of the Kent State University campus. The

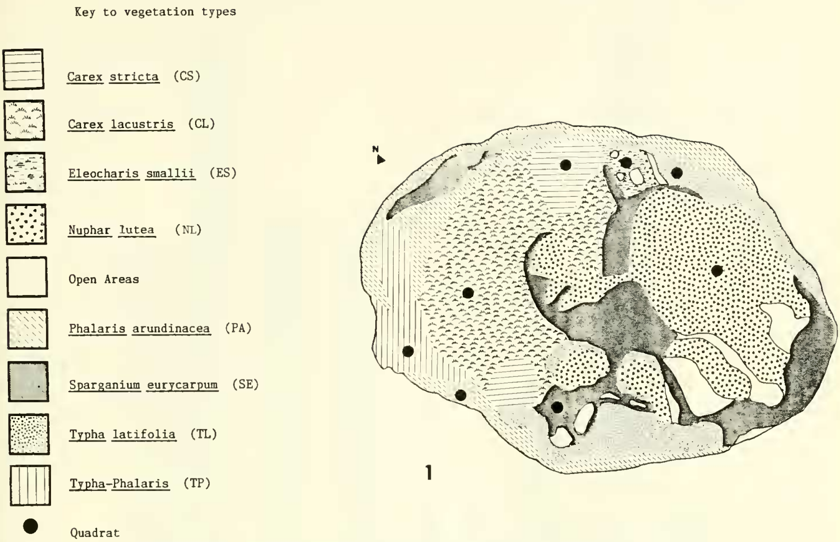


Fig. 1. Map of freshwater marsh showing distribution of 8 vegetation types.

marsh measured approximately 0.5 h and contained a spatial mosaic of 8 vegetation types, most of which existed in nearly monoculture condition (Fig. 1): *Phalaris arundinacea* L. (canary reed grass), *Typha-Phalaris* (equally divided between cattail and grass), *Carex lacustris* Willd. (sedge), *Carex stricta* Lam. (sedge), *Eleocharis smallii* Britt. (spike rush), *Typha latifolia* L. (broad-leaved cattail), *Nuphar lutea* (L.) Sibth. & Smith (yellow water lily), and *Sparganium eurycarpum* Engelm. (burreed). Open areas, represented by standing water or bare substrate, were located within some of the vegetation types.

For collecting purposes, a 5 × 10 m quadrat was established within each vegetation type. Sampling for adult ephydrids was conducted between June and October, 1984, by using a simplified version of the pan trap described by Grigarick (1959). A 38.5 × 14.0 × 4.5 cm yellow plastic container was filled with a detergent-water solution to a depth of approximately 2 cm. Yellow was chosen because Disney et al. (1982) found it to be most effective in collecting Diptera from grass-like areas. One pan was placed in the center of each quadrat biweekly, and left in place for 24 hours. Trapped insects were removed and stored in 70% ethyl alcohol. Additional specimens were obtained by sweeping vegetation with a standard 30.5 cm aerial insect net. Sweeping was conducted biweekly before placement of the pan traps and consisted of 10 back and forth sweeps along the 10 m center line of each quadrat. All sweep sampling was done in the early afternoon hours.

Adult flies obtained from sweeps and pan traps were combined to attain species lists for Ephydridae occurring in each vegetation type. Relative abundance and percent presence values were calculated for all species collected from each vegetation type. Relative abundance values were further categorized according to the method developed by Scheiring and Foote (1973) and were defined as follows: 1–2%, rare (r); 3–8%, oc-

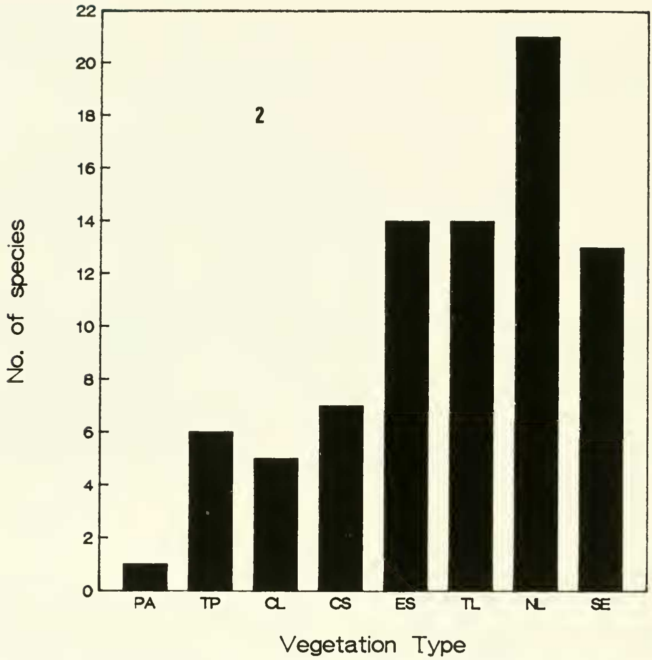


Fig. 2. Number of species of Ephydridae collected in 8 vegetation types of the freshwater marsh.

casional (occ); 9–14%, common (c); 15–25%, abundant (a); and 26–100%, very abundant (va).

As a measure of diversity, the Shannon-Weaver Index (H′) (Pielou, 1966) was used because it incorporates both species richness and evenness. Separate measures of diversity (H′), richness (s), and evenness (J′) were calculated for each vegetation type, each collection date, and each month (June–October) within each vegetation type.

The degree of ephydrid similarity among the vegetation types was calculated according to Morisita's Index (Morisita, 1959). Morisita's Index ranges from 0 (no similarity) to 1 (complete similarity), and refers to the probability that individuals randomly drawn from each of two vegetation types will belong to the same species, relative to the probability of randomly selecting a pair of individuals of the same species from one of the vegetation types.

## Results

A total of 1304 ephydrids of 25 species and 11 genera was collected from the 8 quadrats established within the marsh (Table 1). *Nuphar lutea* contained the highest species richness (Fig. 2) and number of individuals (Fig. 3). Species richness in the marsh increased fairly steadily from the onset of the study in early June (12 spp.) to a peak in mid-July (16 spp.) (Fig. 4). From August to mid-September, species richness remained fairly constant ($\bar{x}$ = 13) but dropped drastically at the end of September (3 spp.). A secondary peak occurred in early October (9 spp.), followed by another decrease at the end of the study in late October (4 spp.). Most individuals of Ephydridae

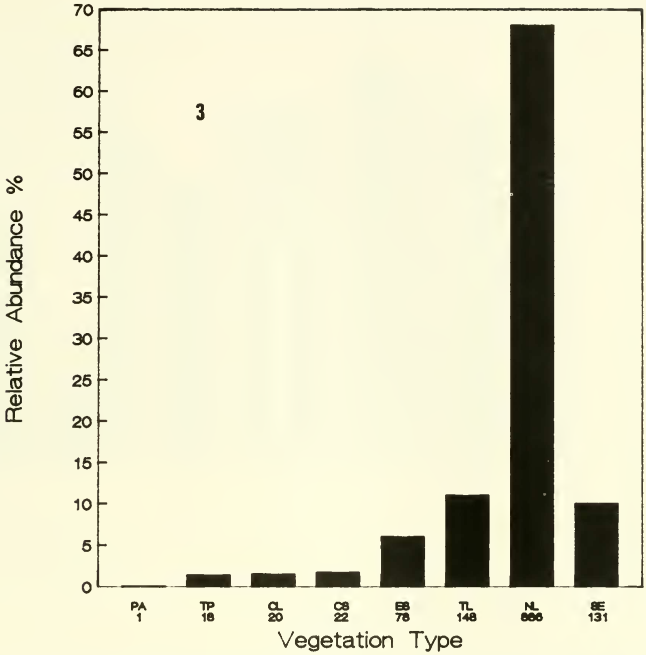


Fig. 3. Relative abundance of species of Ephydridae collected in 8 vegetation types of the freshwater marsh.

were collected in late June, mid-July and late August (Fig. 5).

Values for s, H′, and J′ were obtained for each vegetation type in the marsh (Table 2). Species richness was highest in *N. lutea* (21), followed by *E. smallii* and *T. latifolia*, both with 14 species. High diversity values were found in *T. latifolia* (0.92), *E. smallii* (0.92), and *S. eurycarpum* (0.85). The J′ values indicate that individuals were most evenly distributed among the component ephydrid species in *Typha-Phalaris* (0.86), followed by *E. smallii* (0.80) and *T. latifolia* (0.80).

Similarly, values for s, H′, and J′ were obtained for each sampling date (Table 3). Species richness was highest in mid-July (16), whereas the highest diversity value was obtained in early July (1.03). The J′ values indicate that individuals were most evenly distributed among the component species in early July (0.87) and early August (0.82).

Values for s, H′, and J′ were also obtained for each vegetation quadrat during each of the 5 months of the study (Table 4). Values obtained for quadrats containing 10% or more of the total number of ephydrids collected from the marsh are discussed here. Those quadrats are: *N. lutea* (68%), *T. latifolia* (11%), and *S. eurycarpum* (10%). *Typha latifolia* had the most species (10) in June and July; *N. lutea* (15), in August; and *S. eurycarpum* (10), in July. *Typha latifolia* (0.82), and *S. eurycarpum* (0.81) had their highest diversities in June, and *N. lutea* (0.81) had its highest diversity in July. Peak evenness was found in August for *T. latifolia* (0.96), in October for *N. lutea* (0.73), and in September for *S. eurycarpum* (0.97).

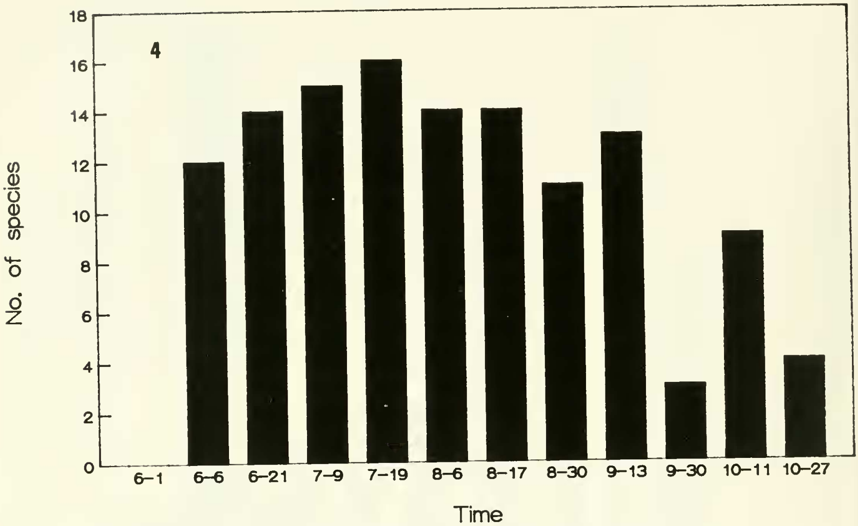


Fig. 4. Number of species of Ephydridae occurring at 12 time intervals in the freshwater marsh.

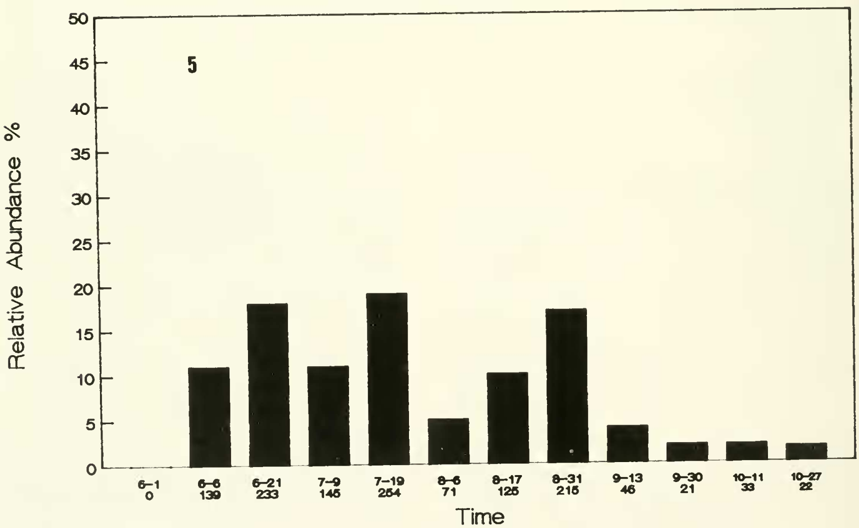


Fig. 5. Relative abundance of species of Ephydridae occurring at 12 time intervals in the freshwater marsh.

Table 1. Species of Ephydridae collected in a freshwater marsh.

| |
|---|
| *Brachydeutera argentata* (Walker) |
| *Dichaeta caudata* (Fallén) |
| *Discocerina obscurella* (Fallén) |
| *Hydrellia cruralis* Coquillett |
| *Hydrellia discursa* Deonier |
| *Hydrellia griseola* (Fallén) |
| *Hydrellia harti* Cresson |
| *Hydrellia* spp. (females) |
| *Lytogaster excavata* (Sturtevant and Wheeler) |
| *Notiphila adjusta* Loew |
| *Notiphila avia* Loew |
| *Notiphila bella* Loew |
| *Notiphila deonieri* Mathis |
| *Notiphila eleomyia* Mathis |
| *Notiphila nudipes* Cresson |
| *Notiphila olivacea* Cresson |
| *Notiphila pauroura* Mathis |
| *Notiphila scalaris* Loew |
| *Notiphila solita* Walker |
| *Notiphila taenia* Mathis |
| *Notiphila* n. sp. |
| *Notiphila* spp. (females) |
| *Ochthera anatolikos* Clausen |
| *Paracoenia fumosalis* Cresson |
| *Scatella stagnalis* (Fallén) |
| *Setocera atrovirens* (Loew) |
| *Typopsilopa atra* Loew |

All vegetation quadrats were compared for similarity of ephydrid species (Table 5). The ephydrid community in *Nuphar* showed very low similarity (0.22–0.31) to those found in any other vegetative type. In contrast, the ephydrid community in *Phalaris* was similar to that in *C. lacustris* (0.96); *Typha-Phalaris* was very similar to *C. stricta* (0.99) and quite similar to *Sparganium* (0.92); *C. lacustris* was very similar to *C. stricta* (0.97); *C. stricta* was quite similar to *Eleocharis* (0.92); and *Typha* was quite similar to *Sparganium* (0.91).

Field collections indicate that *N. lutea* produced 84% of all ephydrid species and 68% of all ephydrid individuals taken during the study (Figs. 2, 3). A total of 886 individuals was collected in this vegetation type, comprising seven genera and 21 species (Table 6). *Notiphila* spp. dominated the *Nuphar* association, comprising 76% of the total ephydrids collected. Three species were collected exclusively from water lily vegetation. *Notiphila eleomyia* Mathis was very abundant (42%), *Notiphila bella* Loew was abundant (22%), and an undescribed species of *Notiphila* was occasional (3%). *D. caudata* (Fallen) was also common in *Nuphar* (14%). *Notiphila bella* was mainly collected between early June and early August, with peak emergence in early June (Table 7). This species occurred in 50% of the samples taken during the study (Table 6). *Notiphila eleomyia* was collected between early June and mid-July, and between mid-August and mid-October. Peak abundances were reached in late June and late August (Table 7). This species was a fairly constant member of the *Nuphar* ephydrid fauna, as

Table 2. Species richness (s), diversity (H′), and evenness (J′) of Ephydridae in 8 marsh vegetation types.

| Vegetation | s | H′ | J′ |
|---|---|---|---|
| PA | 1 | 0.00 | 0.00 |
| TP | 6 | 0.67 | 0.86 |
| CL | 5 | 0.39 | 0.56 |
| CS | 7 | 0.62 | 0.73 |
| ES | 14 | 0.92 | 0.80 |
| TL | 14 | 0.92 | 0.80 |
| NL | 21 | 0.81 | 0.61 |
| SE | 13 | 0.85 | 0.76 |

Table 3. Temporal species richness, diversity, and evenness in marsh Ephydridae.

| Date | s | H′ | J |
|---|---|---|---|
| 6-1 | 0 | 0.00 | 0.00 |
| 6-6 | 12 | 0.58 | 0.53 |
| 6-21 | 14 | 0.68 | 0.59 |
| 7-9 | 15 | 1.03 | 0.87 |
| 7-19 | 16 | 0.87 | 0.72 |
| 8-6 | 14 | 0.95 | 0.82 |
| 8-17 | 14 | 0.91 | 0.79 |
| 8-30 | 11 | 0.66 | 0.66 |
| 9-13 | 13 | 0.91 | 0.81 |
| 9-30 | 3 | 0.26 | 0.54 |
| 10-11 | 9 | 0.59 | 0.61 |
| 10-27 | 4 | 0.38 | 0.62 |

Table 4. Temporal values for ephydrid species richness (s), diversity (H′), and evenness (J′) in 8 marsh vegetation types.

| | June | | | July | | | August | | | September | | | October | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Veg. Type | s | H′ | J′ | s | H′ | J′ | s | H′ | J′ | s | H′ | J′ | s | H′ | J′ |
| PA | 0 | — | — | 0 | — | — | 0 | — | — | 1 | — | — | 0 | — | — |
| TP | 1 | 0.00 | — | 4 | 0.52 | 0.86 | 2 | 0.28 | 0.92 | 0 | 0.00 | — | 0 | — | — |
| CL | 1 | 0.00 | — | 3 | 0.38 | 0.79 | 4 | 0.60 | 1.00 | 1 | — | — | 1 | 0.00 | — |
| CS | 0 | — | — | 2 | 0.28 | 0.92 | 6 | 0.66 | 0.85 | 1 | 0.00 | — | 1 | 0.00 | — |
| ES | 0 | — | — | 6 | 0.70 | 0.90 | 10 | 0.95 | 0.95 | 5 | 0.40 | 0.58 | 4 | 0.52 | 0.86 |
| TL | 10 | 0.82 | 0.82 | 10 | 0.81 | 0.81 | 6 | 0.75 | 0.96 | 1 | 0.00 | — | 1 | 0.00 | — |
| NL | 9 | 0.47 | 0.49 | 14 | 0.81 | 0.70 | 15 | 0.80 | 0.68 | 10 | 0.64 | 0.64 | 7 | 0.62 | 0.73 |
| SE | 9 | 0.81 | 0.85 | 10 | 0.73 | 0.73 | 7 | 0.77 | 0.91 | 5 | 0.68 | 0.97 | 4 | 0.57 | 0.95 |

it occurred in 75% of the samples taken (Table 6). The undescribed *Notiphila* sp. was less patterned in occurrence, attaining slight peaks in abundance during late June and late August (Table 7). This species was obtained in 25% of the samples taken (Table 6). *Dichaeta caudata* was collected between early June and late August, and between late September and late October with peak abundance in late August (Table 7). This species occurred in >80% of the samples taken (Table 6).

## Discussion

Wetland habitats have long been recognized as supporting a relatively rich ephydrid fauna (Dahl, 1959; Deonier, 1965; Scheiring and Foote, 1973; Busacca and Foote, 1978). Comparison of the quantitative variables s, H′, and J′ in this study indicates that differences exist among the ephydrid communities associated with various marsh vegetation types. *Nuphar lutea*, *T. latifolia*, and *S. eurycarpum* contained relatively large and diverse ephydrid assemblages, with species of *Notiphila* being among the more common ephydrids encountered. In northeastern Ohio, Busacca and Foote (1978) repeatedly collected 4 species of *Notiphila* from a marsh containing cattails, sedges, spike rushes, and true rushes. The present study indicates that *N. lutea* also represents a particularly suitable habitat for many *Notiphila* spp., with their abundance probably the result of several interacting factors. The water lilies grew in approximately 25–30 cm of water throughout the study period. Whether the presence of standing water had a direct effect on Diptera in the marsh was not determined, but other authors have examined its importance. Thier and Foote (1980) reported that periodic inundation had a significant positive effect on the population growth of several

Table 5. Ephydrid community similarity in 8 marsh vegetation types.

| | PA | TP | CL | CS | ES | TL | NL | SE |
|---|---|---|---|---|---|---|---|---|
| PA | — | 0.64 | 0.96 | 0.83 | 0.64 | 0.35 | 0.23 | 0.68 |
| TP | | — | 0.82 | 0.99 | 0.90 | 0.85 | 0.29 | 0.92 |
| CL | | | — | 0.97 | 0.80 | 0.26 | 0.28 | 0.57 |
| CS | | | | — | 0.92 | 0.70 | 0.29 | 0.79 |
| ES | | | | | — | 0.68 | 0.31 | 0.78 |
| TL | | | | | | — | 0.22 | 0.91 |
| NL | | | | | | | — | 0.24 |
| SE | | | | | | | | — |

ephydrid species associated with a mud shore, although Cameron (1976) noted that adult insects were not affected by inundating tides in a California salt marsh. Larvae of *Notiphila* spp. are not affected by standing water and survive submerged while feeding on anaerobic sediments because they obtain oxygen through sharp spiracular spines that are inserted periodically into intercellular spaces in the roots of aquatic plants (Busacca and Foote, 1978). During October and November, 1985, over 30 third-instar larvae of *Notiphila* spp. were obtained from mud surrounding *Nuphar* roots, suggesting that the life cycle of species of this genus can be completed in the *Nuphar* association. This method of obtaining oxygen while living in anaerobic sediments may explain, in part, the abundance of *Notiphila* in *Nuphar*.

The occurrence of certain ephydrids in *N. lutea* may also be influenced by the availability of potential food resources, such as broad leaves, thick stems, and bulbous flowers. However, there is no evidence that adult *Notipihila* are capable of utilizing water lily vegetation itself as a food source. According to Waitzbauer (1976), *Notiphila* adults usually feed on fluids of decaying plant material. Utilization of *Nuphar* pollen and nectar by adult *Notiphila* is also known (van der Velde and Brock, 1980). However, water lily vegetation may indirectly enhance food availability for larvae of *Notiphila* spp. Water lilies in the marsh were continually in various stages of decomposition, reaching a maximum in mid-August. Decaying *Nuphar* leaves have been shown to harbor a rich microflora (Wallace and O'Hop, 1984), and larvae of many *Notiphila* spp. ingest microorganisms associated with decaying vegetation (Busacca and Foote, 1978). Similarly, both larvae and adults of *D. caudata* are scavengers on bacteria and yeasts associated with plant detritus (Scheiring and Foote, 1973). The continual decomposition of water lilies may thus provide a high quality food resource.

Table 6. Ephydridae collected from the yellow water lily vegetation type.

| Species | No. of Inds. | Relative Abundance | Percent Presence |
|---|---|---|---|
| *B. argentata* | 12 | 1.35 | 25.00 |
| *D. caudata* | 127 | 14.33 | 83.33 |
| *H. cruralis* | 2 | 0.23 | 8.33 |
| *H. discursa* | 22 | 2.48 | 25.00 |
| *H. griseola* | 18 | 2.03 | 41.67 |
| *H. harti* | 1 | 0.11 | 8.33 |
| *Hydrellia* spp. | 6 | 0.68 | 33.33 |
| *N. bella* | 194 | 21.90 | 50.00 |
| *N. deonieri* | 6 | 0.68 | 8.33 |
| *N. eleomyia* | 369 | 41.65 | 75.00 |
| *N. nudipes* | 17 | 1.92 | 33.33 |
| *N. olivacea* | 5 | 0.56 | 25.00 |
| *N. pauroura* | 13 | 1.47 | 25.00 |
| *N. scalaris* | 3 | 0.34 | 16.67 |
| *N. solita* | 5 | 0.56 | 16.67 |
| *N. taenia* | 4 | 0.45 | 16.67 |
| *Notiphila* n. sp. | 24 | 2.71 | 25.00 |
| *Notiphila* spp. | 36 | 4.06 | 58.33 |
| *O. anatolikos* | 1 | 0.11 | 8.33 |
| *S. stagnalis* | 19 | 2.14 | 41.67 |
| *S. atrovirens* | 2 | 0.23 | 16.67 |
| Total species = 21 | | Total inds. = 886 | |

Although the availability of food resources for adults and larvae is likely to be the most important factor contributing to the large and diverse ephydrid fauna in *N. lutea,* these flies require much more from this plant than just a food source; they also require hiding places from predators, protection from adverse weather conditions, and oviposition sites. In all these respects, the structural complexity of *N. lutea* may render it more suitable for ephydrid utilization than the other marsh plants. The broad, flat leaves of *Nuphar* formed a dense covering over the surface of the water for most of the study, and were held above the substrate at various heights by thick stems. Ephydrid adults may have been able to escape predation by hiding among the various layers of vegetation much more effectively in *Nuphar* than in the other marsh plants, which were structurally much simpler, consisting of straight, slender leaf blades or unbranched stalks. Similarily, *Nuphar* leaves

Table 7. Temporal distribution of Ephydridae in the yellow water lily vegetation type.

| | June | | | July | | Aug. | | | Sept. | | Oct. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 1 | 6 | 21 | 9 | 19 | 6 | 17 | 30 | 13 | 30 | 11 | 27 |
| *B. argentata* | — | — | — | — | 10 | — | 1 | — | — | — | — | — |
| *D. caudata* | — | 1 | 2 | 2 | 4 | 8 | 35 | 55 | — | 2 | 9 | 9 |
| *H. cruralis* | — | — | — | — | — | — | — | — | 2 | — | — | — |
| *H. discursa* | — | — | — | — | 6 | — | 1 | 19 | — | — | — | — |
| *H. griseola* | — | — | — | — | 1 | — | 9 | 7 | 1 | — | — | 1 |
| *H. harti* | — | — | — | — | — | — | — | — | — | — | — | — |
| *Hydrellia* spp. | — | — | — | — | — | 2 | 2 | 1 | 1 | — | — | — |
| *N. bella* | — | 93 | 34 | 16 | 36 | 9 | — | 6 | — | — | — | — |
| *N. deonieri* | — | — | — | — | 6 | — | — | — | — | — | — | — |
| *N. eleomyia* | — | 7 | 129 | 4 | 88 | — | 23 | 101 | 13 | 3 | 1 | — |
| *N. nudipes* | — | — | 1 | 5 | 10 | — | 1 | — | — | — | — | — |
| *N. olivacea* | — | — | 2 | — | — | 2 | — | 1 | — | — | — | — |
| *N. pauroura* | — | — | 2 | — | 9 | — | — | 2 | — | — | — | — |
| *N. scalaris* | — | — | — | — | 2 | 1 | — | — | — | — | — | — |
| *N. solita* | — | — | — | — | 4 | — | — | 1 | — | — | — | — |
| *N. taenia* | — | — | 3 | 1 | — | — | — | — | — | — | — | — |
| *Notiphila* n. sp. | — | — | 9 | — | 3 | — | — | 10 | 2 | — | — | — |
| *Notiphila* spp. | — | — | 5 | 10 | 9 | — | 7 | 3 | 1 | — | — | 1 |
| *O. anatolikos* | — | — | — | — | — | — | — | — | 1 | — | — | — |
| *S. stagnalis* | — | — | — | — | 5 | 5 | 6 | 2 | — | — | 1 | — |
| *S. atrovirens* | — | — | — | — | — | — | — | 1 | — | — | 1 | — |

may have aided in protecting adult Ephydridae from adverse weather conditions. For example, the varying heights of water lily leaves could offer ephydrids shelter from intense sunlight, thereby guarding against desiccation, or provide protection from heavy rainfall and strong winds. Oviposition sites available in *N. lutea* include thick stems, large flowers, and broad leaves. Observations made during this study revealed that *Nuphar* flowers served as an important oviposition site for *Notiphila* spp. During early June, 1985, many *Notiphila* eggs were discovered inside *Nuphar* flowers at the base of the petals, often in small clusters of 5–10 eggs.

In summary, collection data indicate that the Ephydridae form a dominant dipteran family in a northeastern Ohio freshwater marsh, with species of *Notiphila* being especially abundant. Utilization of different vegetation types appeared to be important in structuring the ephydrid community, with the majority of species and individuals collected from the yellow water lily, *N. lutea*. The flight period for most species was between late June and late August, with peak emergence in mid-July. The availability of food resources is suggested as the most important factor influencing the abundance of shore flies in *Nuphar*. The ability of certain ephydrid larvae to survive submerged in water, and the structural complexity of *Nuphar* vegetation are also suggested as influencing ephydrid community organization in that particular vegetation type.

## Acknowledgments

We are indebted to B. K. Andreas, Cuyahoga Community College in Cleveland, Ohio, for aid in determining species of plants found in the study site and to A. D. Huryn, Department of Entomology at the University of Georgia, for determining species of *Notiphila*. This research was supported by a grant (DEB-79 12242) from the National Science Foundation.

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